species thereby maintaining the condition of the species. At a minimum, CALFED actions will not contribute to the need to list a species or degrade the status of a listed species.

GOAL 2: ECOLOGICAL PROCESSES

Rehabilitate natural processes in the Bay-Delta estuary and its watershed to fully support, with minimal ongoing human intervention, natural aquatic and associated terrestrial biotic communities and habitats, in ways that favor native members of those communities.

OBJECTIVE 1: Establish and maintain hydrologic and hydrodynamic regimes for the Bay and Delta that support the recovery and restoration of native species and biotic communities, support the restoration and maintenance of functional natural habitats, and maintain harvested species.

RATIONALE: The restoration of most, if not all, of the native species and habitats in the Bay-Delta estuary depends on having dynamic hydrologic and hydrodynamic regimes (freshwater inflow, salinity, and Delta water circulation patterns) that approximate the historic regimes in order to create conditions favorable for all phases of the life cycles of the "key" fish species (listed in goals 1 and 3). The principal measure in place today of the suitability of the hydrologic and hydrodynamic regime for key fish species is X2, which indicates the position of the salinity gradient in the estuary.

One area in which the hydrologic regime could be altered to favor native species is the Delta. Before the development of water projects, the Delta was less saline in the spring and more saline in the summer during severe droughts than it is now. Highly variable flow and salinity conditions, including infrequent high-salinity events in the Delta, would therefore presumably favor native over introduced species.

As more is learned about the hydrodynamics of the estuary, especially the importance of the low-salinity zone and restoring flow patterns in Delta channels that support estuarine processes related to the food web and fish spawning, rearing, and migration, direct and indirect modifications of estuarine hydrodynamic and hydrologic regimes (in an adaptive management context) should continue.

OBJECTIVE 2: Increase estuarine productivity and rehabilitate estuarine food web processes to support the recovery and restoration of native estuarine species and biotic communities.

RATIONALE: The abundance of many species in the estuary may be limited by low productivity at the base of the food web in the estuarine ecosystem. The causes of this are complex and not well understood, but may include a shortage of productive shallow-water regions such as marshes, high turbidity in open-water regions of the estuary, and consumption and sequestering of available organic carbon by the Asiatic clam. Solving the problem directly is difficult but presumably other actions taken as part of the ERP, such as increasing the acreage of tidal marshlands, will contribute to the solution. A major obstacle to solving problems of estuarine productivity is our poor understanding, so solutions will have to come from research and monitoring of effects of various ecosystem restoration projects.

OBJECTIVE 3: Rehabilitate natural processes to create and maintain complex channel morphology, in-channel islands, and shallow water habitat in the Delta and Suisun Marsh.

RATIONALE: There is widespread agreement that more shallow water habitat needs to be created in the Delta and that existing shallow water habitat needs to be maintained. However, opinions differ on whether creating more habitat will actually increase abundance of desirable species. Ecosystem-based restoration is predicated on this assumption, but adaptive management demands that it be rigorously tested. Staged implementation will allow an increase in confidence in whether or not habitat restoration in the estuary will result in higher abundance of desirable species. Initially this shallow water habitat will be along Delta and Suisun Marsh channels or on small islands in the channels. Ultimately, much of this shallow water habitat would be associated with the restoration of large expanses of tidal emergent wetland, tidal channels, and tidal perennial wetlands in the Delta and Suisun Marsh (recreating large contiguous blocks of the original channel-marsh system). The desirable physical and biotic characteristics of these habitats may be created artificially at first, but the expectation is that they will be maintained by natural processes (e.g., tidal flux, sediment inputs from upstream).

OBJECTIVE 4: Create and/or maintain flow and temperature regimes in rivers that support the recovery and restoration of native aquatic species.

RATIONALE: Virtually all streams in the region are regulated or otherwise modified to some degree, and the altered flow regimes frequently favor non-native fishes. The native fish assemblages (including those with anadromous fishes) are increasingly uncommon. Recent studies in Putah Creek, the Stanislaus River, and the Tuolumne River demonstrate that native fish assemblages can be restored to sections of streams if flow (and temperature) regimes are manipulated in ways that favor their spawning and survival, usually by having flow regimes that mimic natural patterns in winter and spring but that increase flows during summer and fall months (to make up for loss of upstream summer habitats). Native invertebrates and riparian plants may also respond positively to these flow regimes. Similarly, flow regimes in unregulated (naturally flowing) streams that support the restoration and sustenance of native species must be maintained.

OBJECTIVE 5: Establish hydrologic regimes in streams, including sufficient flow timing, magnitude, duration, and high flow frequency, to maintain channel and sediment conditions supporting the recovery and restoration of native aquatic and riparian species and biotic communities.

RATIONALE: Native aquatic and riparian organisms in the Central Valley evolved under a flow regime with pronounced seasonal and year-to-year variability in magnitude, duration, and timing. Frequent (annual or longer term) high flows mobilized gravel beds, drove channel migration, inundated floodplains, maintained sediment quality for native fishes and invertebrates, and maintained complex channel and floodplain habitats. This objective addresses the rehabilitation of at least some of these ecological processes. A strategy of high-flow releases, in conjunction with natural high-flow events, lends itself well to adaptive management because the flows can easily be adjusted to the level needed to achieve specific objectives. However, it should be recognized that channel adjustments may lag behind hydrologic changes by years or decades, requiring long-term monitoring. Also, on most rivers, reservoirs are not large enough to eliminate extremely large, infrequent events so these will continue to affect channel form at irregular, often long, intervals; artificial high-flow events may be needed to maintain desirable channel configurations created during the natural events. This objective is similar to the previous one but differs in its focus on flows that are likely to be higher than those needed to maintain most native fish species but that are important for maintaining in-channel and riparian habitats for fish as well as other species (e.g., invertebrates, birds, mammals). Experimental flow releases also will have to be carefully monitored for negative effects, such as encouraging the invasion of unwanted non-native species. Natural flow regimes, including high flow frequency, in unregulated streams that support the restoration and sustenance of in-channel and riparian habitats should be maintained.

OBJECTIVE 6: Reestablish floodplain inundation and channel-floodplain connectivity of sufficient frequency, timing, duration, and magnitude to support the restoration and maintenance of functional natural floodplain, riparian, and riverine habitats.

RATIONALE: Frequent (often annual) floodplain inundation was an important attribute of the original aquatic systems in the Central Valley and was important for maintaining diverse riverine and riparian habitats. Important interactions between channel and floodplain include overflow onto the floodplain, which (1) reduces the cutting down of the channel, (2) acts as a "pressure relief valve", permitting a larger range of sediment grain sizes to remain on the channel bed, (3) increases the complexity and diversity of instream and riparian habitats, and (4) stores flood water (thereby decreasing flooding downstream). The floodplain also provides shading, food organisms, and large woody debris to the channel. Floodplain forests serve as filters to improve the quality of water reaching the stream channel by both surface flow and groundwater. This objective addresses the reestablishment of active floodplain inundation needed to support these ecological functions.

OBJECTIVE 7: Restore coarse sediment supplies to sediment-starved rivers downstream of reservoirs to support the restoration and maintenance of functional natural riverine habitats.

RATIONALE: One of the major negative effects of dams is the capture of coarse sediments that naturally would pass on to downstream areas. As a result, the downstream reaches can become sediment starved, producing "armoring" of streambeds in many (but not all) rivers to the point where they provide greatly reduced habitat for fish and aquatic organisms and are largely unsuitable for spawning salmon and other anadromous fish.

OBJECTIVE 8: Increase the extent of freely meandering reaches and other pre-1850 river channel forms to support the restoration and maintenance of functional natural riverine, riparian, and floodplain habitats.

RATIONALE: Freely meandering rivers have the highest riparian and aquatic habitat diversity of all riverine systems. Through the process of meandering, eroding concave banks and building convex banks, the channel creates and maintains a diversity of surfaces that support a diversity of habitats, from pioneer riparian plants on newly deposited point bars to gallery riparian forest on high banks built of overbank silt deposits. Similarly, wandering or braided rivers support distinct habitat types and thus are beneficial to aquatic biota. Floodplain restoration can also increase flood protection for urban areas and increase the reliability of stored water supplies in reservoirs (because reservoirs can be maintained at higher levels because of reduced need to catch flood waters).

GOAL 3: HARVESTED SPECIES

Maintain and/or enhance populations of selected species for sustainable commercial and recreational harvest, consistent with the other ERP strategic goals.

OBJECTIVE 1: Enhance fisheries for salmonids, white sturgeon, pacific herring, and native cyprinid fishes.

RATIONALE: Historically the chinook salmon fishery was one of the most economically valuable and the most culturally significant in California. Central Valley salmon and steelhead stocks have been greatly reduced due to dams and other barriers blocking access to spawning habitat, direct mortality from water diversions, altered stream hydrology and Delta hydrodynamics, direct habitat destruction and degradation, harvest pressure, and other stressors. Enhancing salmon and steelhead fisheries will require a coordinated approach of restoring key habitats and ecological processes and reducing or eliminating stressors. Enhancing the fisheries, especially the inland sport fishery, for winter and spring-run chinook salmon and steelhead will be challenging because available habitat is so limited.

White sturgeon represent an unusual situation: a success story in the management of the fishery for a native species. Numbers of sturgeon today are probably nearly as high as they were in the nineteenth century before they were devastated by commercial fisheries. The longevity and high fecundity of the sturgeon, combined with good management practices of the California Department of Fish and Game (CDFG), have allowed it to sustain a substantial fishery since the 1950s, without a major decline in numbers. Numbers of white sturgeon could presumably be increased if the San Joaquin River once again contained suitable habitat for spawning and rearing.

Pacific herring support the most valuable commercial fishery in San Francisco Bay. An important connection to the ERP is that highest survival of herring embryos (which are attached to eel grass and other substrates) occurs during years of high outflow during the spawning period; the developing fish seem to require a relatively low-salinity environment. There is also some indication that populations have been lower since the invasion of the Asiatic clam into the estuary, with the subsequent reduction in planktonic food organisms. Given the frequent collapse of commercial fisheries (including those for herring) in the modern world, it is best to manage this fishery very cautiously to make sure it can continue indefinitely.

Sacramento blackfish, hitch, and splittail support small commercial or sport fisheries. The commercial fisheries are largely unstudied and lightly regulated. Likewise, there is little information on the recreational fishery for splittail in the Delta. Because the ERP seeks to increase populations of native fishes, finding ways to make sure the native cyprinids can support fisheries for specialty markets seems very compatible with the other objectives.

OBJECTIVE 2: Maintain, to the extent consistent with ERP goals, fisheries for striped bass, American shad, signal crayfish, grass shrimp, and nonnative warmwater gamefishes.

RATIONALE: This objective addresses maintaining the popular fisheries provided by these species in a manner that does not conflict with other ERP objectives such as recovery of at-risk native species. The Delta, for instance, has been noted in the past for its productive striped bass and American shad fisheries. Currently these fisheries are depressed while the largemouth bass fishery is in excellent condition. In the absence of a comprehensive restoration effort, increasing the abundance of nonnative fishery species has the potential to limit the recovery of native species, such as chinook salmon and steelhead. Therefore, the management of these species must balance the objective of providing opportunities for harvest while not jeopardizing recovery of native species.

OBJECTIVE 3: Enhance, to the extent consistent with ERP goals, populations of waterfowl and upland game for harvest by hunting and for non-consumptive recreation.

RATIONALE: The Central Valley, Delta, Suisun Marsh, and the rest of the estuary provide important habitat for migratory and resident waterfowl. Public and private seasonal and permanent wetlands and agricultural lands managed to benefit these species following harvest support the impressive flocks of ducks and geese from the Pacific Flyway. While a significant motivation for managing these wetlands has been to support waterfowl hunting, the large associated waterfowl concentrations have become major attractions for large numbers of wildlife viewers, helping to make wetland restoration a much more publicly-supported activity. Much of the primary natural habitats for waterfowl, seasonal wetlands, permanent wetlands, riparian, and grasslands, has been lost or degraded. This has resulted in declines in suitable waterfowl nesting habitat and reductions in the amount of wintering waterfowl habitat. Areas restored to managed seasonal and permanent wetlands and agricultural croplands support increased populations of wintering waterfowl. Management of these habitats with a multi-species perspective will support goals to recover some endangered species.

The upland game guild includes resident and migratory game birds and small mammal game species defined by CDFG hunting regulations. These species are of high interest to recreational hunters in the Bay-Delta watershed. Much of the primary natural habitats for upland game, riparian, oak woodlands, and grasslands, has been lost or degraded. This has resulted in declines in native game species abundances. Agricultural croplands also support upland game. This objective addresses the need to maintain these species by restoring and maintaining the habitats on which they depend.

OBJECTIVE 4: Ensure that chinook salmon, steelhead, trout, and striped bass hatchery, rearing, and planting programs do not have detrimental effects on wild populations of native fish species and ERP actions.

RATIONALE: The salmon, steelhead, trout, and striped bass hatchery, rearing and planting programs in the Bay-Delta watershed were developed to maintain fisheries for these species that would otherwise have ceased or been severely reduced because of habitat loss and degradation, such as dams and diversions blocking access to spawning habitat. To a certain extent, these programs have succeeded by maintaining the commercial and sport fishery for some of these species. Hatcheries and planting programs have not been able to reverse the decline and degradation of wild populations of salmon, steelhead, trout, and other aquatic species. Salmon, steelhead, and trout originating from hatcheries may have aggravated this problem by interacting negatively with wild fish, introducing disease and genetic impacts, and by encouraging high harvest levels in ocean fisheries. Striped bass prey on native fish species, including salmon. There is thus a need to closely evaluate and manage all hatchery and stocking programs that take place in the CALFED area to make sure they are compatible with ERP goals and actions.

A major emphasis of the ERP is to restore wild runs of salmon and steelhead by improving habitat conditions for them and by augmenting flows in spawning streams. The role that state, federal, or private hatcheries can play in this recovery is uncertain. For severely depleted stocks (e.g., winter run chinook) hatchery rearing can provide temporary insurance against extinction due to major natural and unnatural events. For more abundant stocks, however, hatcheries producing large numbers of salmon have the potential to confuse and contravene efforts to restore salmon and steelhead using natural means. Clearly the role of hatcheries on every run of salmon and steelhead needs to be carefully evaluated to determine if and how hatchery practices should be changed or if artificial propagation of some stocks should be halted completely.

GOAL 4: HABITATS

Protect and/or restore functional habitat types in the Bay-Delta estuary and its watershed for ecological and public values such as supporting species and biotic communities, ecological processes, recreation, scientific research, and aesthetics.

OBJECTIVE 1: Restore large expanses of all major habitat types, and sufficient connectivity among habitats, in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include tidal marsh (fresh, brackish, and saline), tidal perennial aquatic (including shallow water and tide flats), nontidal perennial aquatic, tidal sloughs, midchannel island and shoal, seasonal wetlands, riparian and shaded riverine aquatic, inland dune scrub, upland scrub, and perennial grasslands.

RATIONALE: All major natural habitat types in the Delta, Suisun Bay, Suisun Marsh, and San Francisco Bay have been reduced to a small fraction of the area they once occupied, resulting in a large number of at-risk plant and animal species and an increased susceptibility of the remaining areas to irreversible degradation (e.g., invasion by non-native species). The reduction trend is continuing and will have to be reversed if self-sustaining examples of these habitats, and the diverse organisms they support, are to persist into the future. The major habitat types to be restored are stated above in the objective. Within these broad habitat types are more narrowly defined habitats that also need special attention. For example, among the tidal shallow water habitats are intertidal mudflats which are major foraging and resting habitat for migratory and resident shorebirds and waterfowl. Ideally, the mudflats should be dynamic, changing in area and composition in response to freshwater flow and tides. Many are being invaded by non-native cordgrasses which turns mudflat into marsh with relatively low biodiversity. The tendency of this habitat to disappear needs to be reversed through active programs such as cordgrass control. In order to make restoration actions systematic and cost-effective, specific implementation objectives need to be established for each of the habitat types, as well as subhabitats that have distinctive ecological characteristics, and then priorities set within each objective for protection and restoration activities.

OBJECTIVE 2: Restore large expanses of all major aquatic, wetland, and riparian habitats, and sufficient connectivity among habitats, in the Central Valley and its rivers to support recovery and restoration of native species and biotic communities and rehabilitation of ecological processes. These habitat types include riparian and shaded riverine aquatic, instream, fresh emergent wetlands, seasonal wetlands, other floodplain habitats, lacustrine, and other freshwater fish habitats.

RATIONALE: The diversity and spatial extent of aquatic, wetland, and riparian habitats are declining in Central Valley watersheds, especially in lowland areas. Each habitat supports a different assemblage of organisms, and quite likely many of the invertebrates and plants are still unrecognized as endemic forms. Thus, systematic restoration of large expanses of the entire array of major aquatic, wetland, and riparian habitats in the region, with sufficient connectivity among habitats, provides some assurances that essential ecological processes will be rehabilitated and maintained and native biota will be protected, preventing future species listings.

OBJECTIVE 3: Protect tracts of existing high quality major aquatic, wetland, and riparian habitat types, and sufficient connectivity among habitats, in the Bay-Delta estuary and its watershed to support recovery and restoration of native species and biotic communities, rehabilitation of ecological processes, and public value functions.

RATIONALE: A widely accepted principle of ecosystem management is that protecting and maintaining tracts of existing viable, high quality habitat is usually more ecologically efficient, effective, and economical, than restoring degraded or lost habitat. Parcels of high quality aquatic, wetland, and riparian habitats that support native biodiversity and natural processes exist in the Bay-Delta estuary and its watershed. Protecting and maintaining tracts of existing high quality habitat to anchor larger scale habitat restoration actions is a crucial step to improving the ecological health of the Bay-Delta estuary and a top ERP priority along with restoring and/or maintaining sufficient connectivity among habitats.

OBJECTIVE 4: Minimize the conversion of agricultural land to urban and suburban uses and maintain open space buffers in areas adjacent to existing and future restored aquatic, riparian, and wetland habitats, and manage agricultural lands in ways that are favorable to birds and other wildlife.

RATIONALE: The CALFED region is one of the most productive agricultural areas in the world, so agricultural lands and practices will continue to have a significant influence on natural habitats in the area. Agricultural land is important as winter feeding grounds for sandhill cranes, various species of geese, and many ducks. It is also frequently important for foraging raptors, such as Swainson's hawk, and other birds. These benefits are lost if the land becomes urbanized and intense land use disturbs or alters adjacent wetlands or aquatic systems. The negative aspects of modern agriculture from an ecological perspective include its heavy use of pesticides and fertilizers, its efficiency of crop harvest (leaving little for wildlife), its capacity to change land use quickly (e.g., from row crops to vineyards) and its ability to efficiently use each acre of land leaving very little permanent habitat at field margins. This objective addresses the need for "open space" buffers or buffer zones of agricultural land that are farmed in environmentally friendly ways between natural habitats and more industrial agriculture lands or urban areas.

OBJECTIVE 5: Manage the Yolo and Sutter Bypasses as major areas of seasonal shallow water habitat to enhance native fish and wildlife, consistent with CALFED Program objectives and solution principles.

RATIONALE: The Yolo and Sutter bypasses are artificial floodplains constructed in the 1920s to reduce or eliminate flooding of Sacramento and other towns. When not flooded, these immense areas are devoted largely to agriculture. When flooded (mostly during wet winters), the Yolo Bypass alone doubles the wetted surface area of the Delta. Recent studies indicate that the bypasses are potentially important spawning areas for splittail and rearing areas for juvenile chinook salmon, as well as for other species. Their potential as seasonal floodplain habitat is just beginning to be appreciated. A major wildlife area has just been established in the Yolo Bypass. Managing the bypasses at least in part for fish and wildlife therefore has considerable potential and is worth investigating closely. Major problems to overcome are making improvements for fish and wildlife compatible with flood control and with agriculture. Because additional bypasses are being planned, the lessons learned in managing the Yolo and Sutter Bypasses may have broad implications.

Goal 5: Nonnative Invasive Species

Prevent the establishment of additional non-native invasive species and reduce the negative ecological and economic impacts of established non-native species in the Bay-Delta estuary and its watershed.

Objective 1: Eliminate further introductions of new species from the ballast water of ships into the Bay-Delta estuary.

Rationale: The introduction of nonnative species in the ballast water of ships has made the estuary the most invaded estuary in the world; a new species is being added about every 14 weeks. New nonnative invasive species can greatly increase the expense and difficulty of restoring the estuary, and potential reduce the value of a restoration project. Aquatic invasions in various locations in the United States and the world also have harmed public health, decimated fisheries, and impeded or blocked water deliveries. Substantial reductions in the number of organisms released via ballast water are readily achievable. Around the world, restrictions and regulations governing management of ballast water and other ballast materials are being promulgated to reduce the introduction of non-native species by this means. Strict controls on ballast water exchange can be an effective strategy for addressing this objective.

Objective 2: Eliminate further introductions of new species from imported marine and freshwater baits into the Bay-Delta estuary and its watershed.

Rationale: Many kinds of marine and freshwater nonnative organisms are used for bait in the Bay-Delta estuary and its watershed. Presently, polychaete worms are shipped live from New England and southeast Asia to the San Francisco Bay Area for use as bait in marine sport fisheries. The New England worms are packed in seaweed which contains many non-native organisms, some of which have been established in San Francisco Bay as a result. This is thus an example of small activity that has the potential for large-scale economic damage (see ballast water rationale). Freshwater bait fishes like the red shiner have been spreading rapidly and now dominate many streams, with unknown impacts on native fishes and on fisheries. They continue to be spread by anglers releasing unused bait. Like marine baits, other new organisms may be brought in as "hitch-hikers" in shipments of bait fishes.

Objective 3: Halt the unauthorized introduction and spread of potentially harmful non-native introduced species of fish or other aquatic organisms in the Bay-Delta and Central Valley.

Rationale: CDFG has long had a policy of not bringing new aquatic species into California to improve fishing. However, illegal introductions continue, such as that of northern pike into Lake Davis. If the highly predatory pike become established in the Sacramento River and Delta, it is quite likely it would have had devastating impact on salmon and native fish populations. There is a need to develop stronger prevention strategies for illegal introductions. The conflict that developed around the necessary elimination of pike from Lake Davis demonstrates the need for developing better public understanding of the need to halt invasions. Education is also needed to make the point that any movement of fish and aquatic organisms by humans to new habitats is potentially harmful, even if the species is already established nearby. Brook trout introduced into a fishless mountain lake, for example, can eliminate the population of mountain yellow-legged frog that lives there, pushing the species further towards endangered species listing.

Objective 4: Halt the release of non-native introduced fish and other aquatic organisms from private aquaculture operations and the aquarium and pet trades into the Bay-Delta estuary, its watershed, and other California waters.

Rationale: Stocks of fishes and invertebrates are imported from other regions for rearing in aquaculture facilities in the Bay-Delta system, and permits are occasionally approved to bring in new species for aquaculture. Numerous examples exist of organisms escaping from aquaculture facilities and becoming established outside of their range. These include, or potentially could include, fish, crayfish and other shellfish that could compete with or prey on native California fish and aquatic organisms, including sport and commercial species. Of greater concern is the potential for the introduction of parasites and diseases to native fish and shellfish, again including fishery species.

Many kinds of aquatic organisms are sold in aquarium and pet stores. It is likely that some species of nuisance aquatic plants (e.g., *Hydrilla*) became established through aquarists dumping them in local waterways. Nonnative turtles originating in pet stores are frequently present in ponds and have the potential to displace and spread diseases to native pond turtles. Although many organisms sold in aquarium stores are tropical and unlikely to survive in Central California (with some surprising exceptions), the industry is constantly searching for and bringing in new species from a variety of habitats. As indicated in the ballast water rationale, new species can have unexpected and sometimes large-scale negative impacts on aquatic ecosystems and can make restoration much more expensive and difficult.

OBJECTIVE 5: Halt the introduction of non-native invasive aquatic and terrestrial plants into the Bay-Delta estuary, its watershed, and other central California waters.

RATIONALE: Many areas of the Central California landscape are dominated by non-native plant species (e.g., annual grasslands, eucalyptus forests) that have displaced native species and have unexpected negative impacts. Parrot's feather, for example, is an ornamental aquatic plant that is now widespread, clogging ponds and ditches in the CALFED area, thereby creating breeding habitat for mosquitoes. Many harmful species (e.g., water hyacinth) can easily be purchased in plant nurseries and so continue to be spread into natural systems. New species and varieties of plants from all over the world are constantly being brought into California with little evaluation of their invasive qualities. Some species (e.g., Atlantic and English cordgrass) have even been imported for marsh restoration projects.

OBJECTIVE 6: Reduce the impact of non-native mammals on native birds, mammals, and other organisms.

RATIONALE: Probably few issues are as potentially contentious to the public as programs to control the numbers of house cats (both tame and feral), red fox (introduced in the Central Valley and spread to marshes throughout the Bay-Delta system), and domestic dogs in natural areas. The fact remains that such predators can have a major impact on the ability of natural areas to support wildlife, including threatened native species such as clapper rails, salt marsh harvest mice, and salt marsh song sparrows. Likewise, non-native rats and mice can impact populations of native rodents and songbirds. Thus there is a major need to educate the public about the tradeoffs in protecting abundant and conspicuous predators that prey on native species, as well as programs to rid areas of other non-native mammals.

OBJECTIVE 7: Limit the spread or, when possible and appropriate, eradicate populations of non-native invasive species through focused management efforts.

RATIONALE: Nonnative invasive species (NIS) are now part of most aquatic, riparian, and terrestrial ecosystems in California. It is usually difficult to control or reduce the spread of NIS. Preventing new introductions is the most practical, economical, and environmentally safe strategy for dealing with NIS. However, in some instances, control and/or eradication of invasive species is needed (and feasible) to protect the remaining native elements or to support human uses. Four factors should be considered in focusing control efforts. First, an introduced species is often not recognized as a problem by society until it has become widespread and abundant. At that point, control efforts are likely to be difficult, expensive, and relatively ineffective, while producing substantial environmental side effects or risks, including public health risks. Second, some organisms, by nature or circumstance, are more susceptible to control than others. Rooted plants are in general more controllable than mobile animals, and organisms restricted to smaller, isolated water bodies are in general more controllable than organisms free to roam throughout large, hydrologically connected systems. Third, although biological control is conceptually very appealing, it is rarely successful and always carries some risk of unexpected side effects, such as an introduced control agent "controlling" desirable native species. And fourth, physical or chemical control methods used in maintenance control rather than eradication require an indefinite commitment to ongoing environmental disturbance, expense, and possibly public health risks. Overall, the most efficient, cost-effective, and environmentally beneficial control programs may be those that target the most susceptible species, and species that are not yet widespread and abundant. This suggests a need to (1) assess the array of introduced species and focus on those that are most amenable to containment and eradication, rather than focusing just on those that are currently making headlines, and (2) responding rapidly to eradicate new introductions rather than waiting until they spread and become difficult or impossible to eradicate.

An example of an introduced species with currently limited distribution needing eradication that is only beginning to be dealt with is Atlantic smooth cordgrass (*Spartina alterniflora*) in San Francisco Bay. Replacing open mudflats and native cordgrass communities with monospecific stands, smooth cordgrass is a substantial threat to aquatic organisms, wildlife, and fisheries in Pacific estuaries. For example, it densely covers about 30% of the intertidal area of Willapa Bay, Washington. Its introduction into San Francisco Bay has resulted in rapid colonization of the south end of the bay. It has the potential to spread throughout the estuary. However, because of its present relatively limited distribution and abundance, smooth cordgrass can readily be eradicated using appropriate methods.

An example of an abundant species needing immediate attention is the water weed *Egeria densa*. This plant has been spreading rapidly through the Delta, where it clogs sloughs and channels with its dense growth, creating problems for navigation. From a biological perspective, it is undesirable because *E. densa* beds appear to exclude native fishes and favor introduced species.

OBJECTIVE 8: Prevent the invasion of the zebra mussel into California.

RATIONALE: The zebra mussel has done enormous damage to water supply infrastructure and to natural ecosystems in the eastern United States, through which they are spreading rapidly. It is likely that at some point a live population of zebra mussels will appear in California waters through any one of several means. Studies have already demonstrated that it will likely thrive in many parts of the California water system. Therefore, it is highly desirable to have in place a strategy to deal with a localized invasion, along with a commitment of resources from agencies so that rapid action is possible.

GOAL 6: WATER AND SEDIMENT QUALITY

Improve and/or maintain water and sediment quality conditions that fully support healthy and diverse aquatic ecosystems in the Bay-Delta estuary and watershed; and eliminate, to the extent possible, toxic impacts to aquatic organisms, wildlife, and people.

OBJECTIVE 1: Reduce the loadings and concentrations of toxic contaminants in all aquatic environments in the Bay-Delta estuary and watershed to levels that do not adversely affect aquatic organisms, wildlife, and human health.

RATIONALE: Many fish, invertebrates, and wildlife, including at-risk species in Goal 1 and harvested species in Goal 3, contain high levels of heavy metals, pesticides, and other contaminants. There is good reason to think that these toxic compounds may be having negative effects on these organisms, both acute and chronic, including affecting their ability to reproduce, feed, navigate, avoid predation, and/or fight off disease. These same compounds can affect human health through the consumption of harvested species. Systematic reduction in contaminant loads from point and nonpoint sources into the aquatic ecosystems should have positive ecological and human health benefits. In some cases, such as mercury, reduction of concentrations to safe levels may be difficult because of deposits in sediments, but strategies to reduce loads and concentrations are still necessary. This objective addresses CALFED environmental water quality parameters of concern identified by the CALFED Water Quality Technical Group including mercury, pesticides, selenium, trace metals, and toxicity of unknown origin.

OBJECTIVE 2: Reduce loadings of oxygen-depleting substances from human activities into aquatic ecosystems in the Bay-Delta estuary and watershed to levels that do not cause adverse ecological effects.

RATIONALE: As a result of the Clean Water Act, local, regional, state and federal agencies have greatly decreased the amount of contamination of California's waters by sewage, animal wastes, and other substances that deplete oxygen in the water. These organic materials and ambient river conditions cause rapid eutrophication, resulting in dominance by undesirable organisms. Such contamination, although diminished, is still common and needs to be reduced further, from both point and non-point sources. For example, low dissolved oxygen levels in the lower San Joaquin River are often a barrier to the upstream movement of adult salmon and other fish. It is worth noting, however, that release of organic nutrients into aquatic systems is not necessarily always harmful, especially if the nutrients derived from human sources essentially replace those no longer entering the system from natural sources.

OBJECTIVE 3: Reduce fine sediment loadings from human activities into rivers and streams to levels that do not cause adverse ecological effects.

RATIONALE: Fine sediment loads from human activities can and has degraded stream and river habitat in the Sacramento River watershed, the San Joaquin River watershed, and tributaries to San Pablo Bay. Sedimentation and turbidity adversely affect the quality and quantity of fish spawning habitat and other benthic stream habitat and organisms. Erosional soil discharges from agricultural lands, road construction and repair, mining sites, and urban/suburban lands in stormwater runoff and in-channel mining and dredging activities are the major anthropogenic sources of fine sediment loads into streams.